March 14, 2005

NETS

navigation · economics · technologies

ESTIMATION OF DEMANDS AT THE POOL LEVEL

US Army Corps
of Engineers®

IWR Report 05-NETS-R-03

Navigation Economic Technologies

The purpose of the Navigation Economic Technologies (NETS) research program is to develop a standardized and defensible suite of economic tools for navigation improvement evaluation. NETS addresses specific navigation economic evaluation and modeling issues that have been raised inside and outside the Corps and is responsive to our commitment to develop and use peer-reviewed tools, techniques and procedures as expressed in the Civil Works strategic plan. The new tools and techniques developed by the NETS research program are to be based on 1) reviews of economic theory, 2) current practices across the Corps (and elsewhere), 3) data needs and availability, and 4) peer recommendations.

The NETS research program has two focus points: expansion of the body of knowledge about the economics underlying uses of the waterways; and creation of a toolbox of practical planning models, methods and techniques that can be applied to a variety of situations.

Expanding the Body of Knowledge

NETS will strive to expand the available body of knowledge about core concepts underlying navigation economic models through the development of scientific papers and reports. For example, NETS will explore how the economic benefits of building new navigation projects are affected by market conditions and/or changes in shipper behaviors, particularly decisions to switch to non-water modes of transportation. The results of such studies will help Corps planners determine whether their economic models are based on realistic premises.

Creating a Planning Toolbox

The NETS research program will develop a series of practical tools and techniques that can be used by Corps navigation planners. The centerpiece of these efforts will be a suite of simulation models. The suite will include models for forecasting international and domestic traffic flows and how they may change with project improvements. It will also include a regional traffic routing model that identifies the annual quantities from each origin and the routes used to satisfy the forecasted demand at each destination. Finally, the suite will include a microscopic event model that generates and routes individual shipments through a system from commodity origin to destination to evaluate non-structural and reliability based measures.

This suite of economic models will enable Corps planners across the country to develop consistent, accurate, useful and comparable analyses regarding the likely impact of changes to navigation infrastructure or systems.

NETS research has been accomplished by a team of academicians, contractors and Corps employees in consultation with other Federal agencies, including the US DOT and USDA; and the Corps Planning Centers of Expertise for Inland and Deep Draft Navigation.

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Estimation of Demands at the Pool Level

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Of Engineers Revealed Choice
Estimate of the Demand for Barges
On the Mississippi River

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This paper summarizes the results of investigations into the demand for the transportation of corn on the Upper Mississippi River and Illinois Waterways during 1991-2002.

This study is of interest for two very different reasons. First, there is ongoing interest in making physical improvements to this particular waterway system, and elasticities of demand are in important element in the valuation of the benefits of infrastructure development. While it is not the intent of this paper to do a benefit analysis for infrastructure improvement, in the pages below, we will describe how these elasticities can be used in such a study. Second, of more technical interest, are lessons that can be learned about practical techniques for freight demand estimation. This study used the extraordinarily detailed data generated by movements on the waterway, which, along with the simplicity of the system, should be an ideal setting for demand estimation. If there are difficulties in the exercise with almost ideal data in the simplest of all networks, then the difficulties will be even larger when the techniques are applied to more complex networks with less detailed data.

This study begins by describing the system studied and by summarizing the data used to estimate the elasticities of demand. Our focus is on pool-level demands and thus the basic unit of observation is quantities of corn shipped from each pool and the price charged for shipping that grain during each of the 144 months between January 1991 and December 2002. This study emphasizes that both prices and shipping patterns reflect strong seasonality, though differing patterns on different parts of the system. While on the surface there appears to be a great deal of variation in prices, once the seasonal pattern is removed, it becomes apparent that there is relatively little overall movement in prices.

For most pools, we find that there is a positive simple correlation between monthly shipping prices and the monthly quantity of corn shipped. We attribute this to the endogeneity of river transport prices and to the fact that there is considerably more variation in the demand for transportation services than in supply. The functional form used in this study is designed to allow for the identification of the demand for transportation.

Using our functional form, we are able to measure a statistically significant inverse relationship between the prices charged to transport corn on the river and the willingness to offer corn to carriers on the river. The elasticities are measured to be quite small, however. This paper ends by noting the difference between short run and long run elasticities of demand and providing some reasons to expect that the long run elasticities that are not measured in this study should be higher than the short run elasticities that are measured here.

Description of the System

The Upper Mississippi/Illinois Waterway system consists of a series of locks and dams shown in Figure 1 allowing for the movement of barges. For the purposes of this study, we have defined a series of pools based primarily on the locks and dams that form the upper and lower boundaries of the stretch of river. The definition of each pool by river mile and by the lock defining the lower boundary of the pool is shown in Table 1. We have numbered the pools on the Upper Mississippi between 1 and 29. The stretches of the Illinois River that we use are numbered between 102 and 109. Higher pool numbers correspond to lower reaches of each river. Pool 30 is on the Upper Mississippi below the last lock, and is thus on the free flowing part of the river. Southbound traffic that leaves both the Illinois and pools 29 and above on the Mississippi pass through Pool 30. It thus belongs to both waterways. Since traffic on this stretch of the river does not pass through locks, it responds differently to congestion than other pools.

Pools

This study deals with monthly shipments of corn that leave the Upper Mississippi and Illinois waterways. Our data covers 1991-2002. All data on tonnages come from the US Army Corps of Engineers Waterborne Commerce Data. The basic observation is the number of tons of corn shipped from a pool during a month.

Pools on the river system differ greatly in the mean number of tons of corn shipped per month. This data is presented in Table 2. As can be seen in this Table, there were some pools (for example, pools 8 and 10) which had no corn shipments at all during the twelve years covered by this study, and several more (pools 5, 7, 12, 14, 103 and 104) which had at most a handful of shipments. Most pools ship a modest amount (10,000-

50,000 tons) of corn per month. The very largest pools, those around the Twin Cities (pool 4) and around Peoria (pool 107,) ship an average of more than 300,000 tons of corn per month. Almost all of the corn that is loaded on barges is destined for export at the Gulf of Mexico.

Pools differ also in the extent to which corn shipments from the pool are increasing or decreasing. This information is given in the last two columns of Table 2. It is not surprising that the pools with only a handful of shipments over the 12 year period show very different numbers in during the first two and last two years of the period. In addition there is apparent stability of shipment levels in some of the largest pools. For example, in both the case of Peoria and the Twin Cities, monthly tonnage levels in 1991-2 were very close to those in 2001-2002. However, for some other pools, there are apparently large structural changes that have taken place over the period. In the middle Mississippi, pools 15-17 lost half of their tonnage between 1991-2 period and 2001-2. Pool 30, by contrast, saw tonnages approximately doubling between the same pairs of years. Similar large shifts are found in a number of other pools. The presence of such large shifts in tonnages in a number of pools suggested that the analysis should allow for structural shifts over the period of the analysis.

Pools differ not only in size and the presence of structural shifts between early and later years, but are also distinct in the seasonality of shipments. This is shown in Table 3 which gives the mean monthly tonnages over the twelve year period for all of the pools. In this table, lines are drawn above and below Pool 30 to emphasize that these are three distinct pieces of river.

Trends and Seasonality of Corn Tonnages

Upper Mississippi and Illinois River corn shipments have different seasonal patterns. Table 3 shows that the top of the Mississippi at Minneapolis has a summer peak. About 500,000 tons of corn are shipped out of Pool 4 during each of May, June, July, and August. April, September and October are shoulder period. No corn is shipped from this pool in December through February. Peoria, by contrast, has the lowest shipping volumes of the year during August-October. The peak shipping month is January, during which 690000 tons are shipped. Pool 30 has a seasonality considerably closer to that of Illinois River pools, with a January peak. The lowest shipping month is June. However, in earlier work, we were able to demonstrate that Pool 30's seasonality shifted over the period from a summer peak like most of the Upper Mississippi to a winter peak.

Figure 2 graphs the total amount of corn shipped on the Upper Mississippi from Pool 3-Pool 29 in each of the 144 months between January 1991 and December 2002. The intense summer seasonality of shipment is apparent. The floods of 1993 are seen in lower shipping volumes between months 24 and 48.

The companion graphs for the Illinois River and for Pool 30 are presented in Figure 3. The top, lighter line is monthly tonnage of all of the Illinois River pools while the lower darker line is the monthly shipments of corn from Pool 30—that is, in the region below the last lock of the river system. The Illinois sees a similar seasonality to that on the Upper Mississippi, though offset by several months. The shift in the seasonality of Pool 30 shipments is also visible, as the base tonnage of seasonal lows has clearly increased in the later years.

A more formal analysis of the trend and seasonality of corn shipments from the three areas is shown in Table 4. This table shows regression coefficients of total tonnages of corn shipped from Pools 3-29, from Illinois River pools, and from Pool 30 over the 144 months of the study. The base month for all three regressions is July. Thus the constant term is the fitted value of July shipments before taking trend into account. The other monthly coefficients show the predicted difference between the July level of shipments and those of each other month. The trend coefficient is the predicted monthly change in corn shipments, once seasonality is accounted for.

The strong summer peak of shipments on the Mississippi is shown in the large constant term and the negative coefficients on months other than summer months. The Illinois River has a much smaller constant term and much larger coefficients on non-summer months. The pattern of monthly coefficients on Pool 30 corn shipments shows two peaks, one in September and one in January.

The trends for both the Mississippi and Illinois rivers are insignificant. In the case of the Mississippi, the passage of a month of time is predicted to lead to 276 fewer tons shipped while the Illinois is expected to see 123 more tons. Both numbers are much smaller than is necessary to be identified as a significant effect. By contrast, Pool 30 shipments increased an average of 1427 tons per month for each month's passage of time, and this is a highly significant positive trend. We noted previously, however, that this increase in tonnage should probably be characterized as a discontinuous increase in tonnage towards the middle of the period under study—a shift that also brought with it a change in the seasonality of shipments. For each stretch of river, trend and seasonality account for approximately 70% of the total variation in monthly tonnage.

Speed and Seasonality

An attraction of studying transportation demand on a river system is the linearity of the system which removes one layer of complexity. Not surprisingly, it takes longer to travel from the northern reaches of the river system than from pools closer to St. Louis. Table 5 shows the mean transit time over the 12 years from each of the pools to the last lock in the system, Lock 27, at the top of Pool 30. It took on average 159.4 hours to sail from Pool 2 to Pool 30 over this period. This speed is calculated for through movements and will in general be faster than tows that stop to re-fleet along the way. The calculation of average transit times was one of the major undertakings of the study. The numbers in Table 5 reflect removal of a quantity of apparently bad data, primarily by using filters that removed records that were either unreasonably fast or slow.

The removal of outliers and the averaging of transit times over a month allows fitting of transit time with a high degree of accuracy. This is seen in the second and third columns of Table 5 which show the smooth decline in travel time as we move south along the Mississippi and the very small standard deviation of monthly average travel times. The data show that while there is enormous variation in the amount that is shipped per month, the southbound transit time is extremely stable from month to month. It takes on average 157.7 hours sailing and lock delay time to move a barge of corn from Pool 3 to Pool 30. In ninety five percent of the months, the average transit times are between 138.5 and 177 hours. In the month with the fastest travel times, it took 135.1 hours on average, while the slowest average monthly travel times were 180.5. In other words, there is little month-to-month variation in average travel time.

The Illinois River similarly has very little variation in travel time. For example, it takes approximately two days for a barge loaded in pool 107 to reach pool 30. The standard deviation is only one tenth of the total travel time, suggesting little month-to-month variation in average travel time.

Table 6 shows regressions of transit time from three large corn exporting pools to the free flowing part of the Mississippi River. The base month is July, which is the slowest month for the Mississippi. According to the regression for Pool 4, the expected transit time for July 1991 from the Twin Cities to the last lock of the Mississippi River system was 159.7 hours. March transit times were predicted to be 19.74 hours faster. For the Illinois, December is the slowest shipping month. In general, the slowest travel times are associated with peak shipping months, presumably due to increased waiting times at locks at congested periods. Distributing the projected 12 year increase in transit times on the Illinois, average July shipping times from Pool 107 increased from about 45.59 hours to 52.32 hours, an increase of about 15%.

Once transit times have been adjusted for expected seasonality, there is little variation left. Part of that variation is, however, associated with an overall slowing of the system. Table 6 shows that over the 144 months of our study, the average monthly transit times, from which seasonality has been removed, increased at the rate of .073 hours for travel from the Twin Cities to St. Louis. This corresponds to an average increase of 10.5 hours. There are similar increases of 8.9 hours from the middle-Mississippi and 5.7 hours from Pool 107. The reader should note that while congestion does lengthen average travel times, this system slowing between 1991 and 2002 can not be due to congestion from increased corn movements since corn shipments from the Upper Mississippi and Illinois neither trended up nor down over this period.

The Construction of Corn Shipping Prices

The US Department of Agriculture maintains a data base of average shipping prices for a ton of corn from three locations on the river system to the Gulf of Mexico, from the Twin Cities, from St. Louis, and from the Illinois river at Beardstown, IL. We deflated by the producer price index to quote these prices in terms of real 1981 dollars. Shipping prices reflect both global supply and demand conditions for barges and equipment as well as local conditions in individual pools. All three rate indices move closely together, with an occasional anomaly, presumably due to local conditions. Since barges are used to carry more than simply corn, prices reflect the supply and demand conditions for all of the commodities carried on the river system.

Figure 4 shows that there is a strong seasonal pattern to the prices for shipping corn from the three locations. The seasonal peaks and valleys are coincident in the case of rates. This is in contrast to the seasonal pattern of quantities where there is a summer peak at the Twin Cities and a winter peak on the Illinois. All three rate series peak in October. Not surprisingly, the highest per ton shipping charges are from the Twin Cities since transportation from that location requires more equipment-hours. The lowest charges are from St. Louis, for the same reason.

The reader will recall that there was little variation in the average transit times for all three of the pools analyzed in Table 6, and that once seasonality and trend were accounted for, there was even less variation remaining. A casual inspection of Figure 4, however, shows that this is not the case with the price of river shipping. There is enormous variation in prices charged per ton, and these prices are different from year to year as well as seasonally.

Table 7 provides a more formal analysis of the trend and seasonality of the three price series used in this study. In July, the real rate charged for shipping a ton corn from the Twin Cities to the Gulf of Mexico is almost double that charged to ship the same ton of corn from St. Louis to the Gulf. In all three series, October rates are about $3 higher than in July. May rates are about one dollar per ton lower at St. Louis and $1.75 lower at the Twin Cities. It is clear that the seasonal pattern of corn shipments from the Twin Cities reflects the lower rates that are available during the Spring.

There is an insignificantly positive trend of 3/10 cent per ton per month to shipping prices at the Twin Cities and the Illinois River. Over 144 months, this will add roughly 54 cents to the price of shipping corn from either location to the Gulf. This should be contrasted with the clear downward trend in shipping prices from St. Louis. Removing the seasonality from the price series, the remaining trend a negative 7/10 of a cent per ton per month or a real reduction of $1 per ton after 144 months. It is reasonable to assume that the increasing divergence between the price of shipping from the pools on the upper Mississippi and Illinois and the price of shipping from Pool 30 (St. Louis) is related to the slowing of transit times on the two rivers.

With price series available at only three locations, but with quantity data available at all pools, we used the pragmatic assumption that the difference between Twin Cities and St. Louis rates could be prorated by the difference in the transit time between the pool in question and Pool 30 versus Pool 4 and Pool 30. Thus, for example, if in some month, the sailing time from the Twin Cities to Pool 30 is double the sailing time from Pool 17 to

Pool 30, we constructed a rate per ton for Pool 17 that is equal to the St. Louis rate plus half of the difference between the Twin Cities to the Gulf rate and the St. Louis to the Gulf rate. The same prorating method was used to construct monthly rates for individual pools on the Illinois River.

The reader will note as well that trend and seasonality in Table 7 have considerably less explanatory power in these regressions than in those shown in Table 6, with only 36% of the total variation explained by trend and seasonality. Since our rates are constructed from the posted rates at three locations and monthly speeds from different pools, the dominant factor in determining these constructed rates will be the rate series rather than speed variation, with increasing weight given to the St. Louis series for lower pools and increasing weight given to the Twin Cities and Illinois rates for higher pools.

Real Ocean Freight Rates

Corn that is placed on the river at the pools in our study is predominantly intended for export at the Gulf of Mexico. A complement to river transportation is then ocean shipping of corn from the Gulf to its ultimate destination, often Asia. The U.S. Department of Agriculture maintains a series of ocean freight rates from the Gulf to Asia, as well as rates for ocean shipping from the Pacific Northwest to Asia. Exporters accessing the Asian market have an alternate route by rail to Portland connected to a less costly ocean voyage to Asia. Thus the spread between the ocean rate from the Pacific Northwest and from the Gulf will affect the relative profitability of using the alternate non-river route for export.

Figure 5 shows the published rate series for bulk shipment of grain to Asia. The top line in Figure 5 shows dollars per ton from the Gulf. The light solid line is the rate per ton from Portland. The difference between the two series is shown as the heavy line at the bottom of Figure 5.

Figure 5 does not show the seasonal variation in prices that was evident in Figure 4. Ocean shipping prices depend on the world-wide supply and demand conditions for the shipment of bulk commodities. Since charter rates for this type of equipment are quoted in dollars per day, the Pacific Northwest will always have lower shipping charges since it takes fewer days to sail from Portland to Asia than from the Gulf. The spread between the two series then depends primarily on the dollars per day charged for a ton of shipping capacity. During this period, the price of ocean shipping was generally declining. At the end of 1998, at the bottom of the Asian currency crisis, the difference between the two series reached historic lows. The spread has recoverd somewhat since that time, but still remains somewhat smaller than through most of the 1990's

Since the profitability of using the Gulf route to Asia depends on both the cost of river transportation to the gulf as well as the cost of ocean transportation, it is interesting to compare the two costs. This is done in Figure 6. The top line is the difference in real dollars per ton for shipping to Asia from the Gulf and from the Pacific Northwest. This difference was approximately $8 per ton from 1991 to 1997, but was only about $4/ton after the Asian currency crisis.

The lower, darker line in Figure 6 shows the ratio of the Difference between real Gulf and real Pacific Northwest to Asia grain shipping costs per ton to the real cost per ton of shipping a ton of grain from St. Louis to the Gulf. This series varies seasonally, as noted previously, but was a remarkably constant ratio of approximately 2 from 1991 to 1997. Following the Asian currency crisis, the series seems fluctuate seasonally around a somewhat lower mean.

The lack of movement in the lower series is disappointing from the perspective of demand estimation. Ideally, we would like to find independent effects of the cost of barge shipping and the cost of ocean shipping. However, once the effect of seasonality is removed, there is not enough independent variation in the two price series to be able to separate the effects of the two price movements. Attempts to distinguish between the demand effects of ocean rates and river rates gave illogical results. We believe that this is due primarily due to the fact that the two series do not have enough independent variation and that the one place where the series did move was in the Asian currency crises which was a disequilibrium position. Nonetheless, it is worth remembering that some of the effect that we attribute to river prices is perhaps alternatively attributable to variations in the ocean freight series which is collinear with it.

Short-run Flexibility in Grain Shipping Decisions

The basic observation in this study is the monthly amount of grain shipped from a pool to the Gulf using the river system. Our aim is to determine the extent to which high shipping prices on the river reduce the amount of grain shipped on the river. As is the tradition in transportation demand analysis, we model the process of determining demand as a sequence of decisions. For purposes of exposition, we will characterize the decision maker as the farmer, though we recognize that the authority to divert grain may be passed to elevators in the system. Grain shipping on the river system is the result of six chained decisions:

1) A farmer decides on the number of acres to devote to corn. This decision is based on the forecast of market conditions for corn at harvest time as well as the forecast of market conditions for other commodities. Farmers in different locations may have different alternative crops that they might plant if market conditions for corn are projected to be poor. The decision on the number of acres of corn to plan is long run and beyond the basic structure of demand modeling attempted here.

2) A farmer decides on the level of attention to devote to the crop based on contemporaneous market conditions as well as growing conditions. If market conditions appear to be poor (perhaps because the cost of river transportation is unusually high,) it is possible that a farmer will forgo an application of fertilizer and thus will harvest a smaller crop.

3) A farmer decides how much of his crop to harvest and how much to plow under based on the net price available to him at the elevator that is in a position to offer the highest net price. If shipping prices to the Gulf are usually high, it is possible that a farmer will not harvest all of the acres that were planted.

4) A farmer decides on the timing of the movement to and release of harvest from storage elevators depending on current conditions and anticipated future market conditions. This factor depends on our ability to model the formation of expectations, something that the economics profession has been notoriously bad about. We can measure whether the price of river transportation is currently unusually high or low, but we can not measure from the data whether these conditions are expected to persist or not. If the high prices are expected to be transient, a rational decision maker might hold the crop in storage and wait for several months until the price of river transportation falls and

thus the price that the farmer received for the crop is higher. If high prices are expected to be permanent, however, there is no advantage in waiting. Since we can not measure expectations, we will use the current price of river transportation as a proxy for the unobserved expectation. Storage decisions represent the first source of short run source of flexibility that a farmer is assumed to have to deal with changing prices for shipping on the river.

5) A farmer decides whether to deliver the harvest (or to allow the release of the harvest from the country elevator where it is stored) to the river for export by water. There are many alternatives to river transportation. For example, the farmer could deliver the harvest to an elevator that would send the harvest by rail or truck to an alternative port (e.g., Duluth or Portland), deliver the grain to a local processor, or delver the grain to an elevator that will load it on a train for delivery to a point that bypasses the lock system. We will give the name “leakage” to the loss of harvest to modes, uses, or destinations or than the delivery to the river for export.

Leakages represent the second of the three basic short- to medium-term sources of flexibility that farmers will have that will determine the elasticity of demand for transportation. We should not presuppose what the best alternative is for each farmer—whether it is rail to a location off of the UMR/IW system, local consumption, or even trucking to a distant port. For this reason, we will not try to model and estimate the geographic structure of alternatives available to each shipper. It is clear that each farmer or elevator will have a different options available and a different ordering of alternatives.

6) A farmer, having decided to deliver the harvest to the river, decides which pool to deliver the harvest to. Farmers can reduce their exposure to high shipping prices or

congestion by delivering grain to a pool farther south on the system. This decision will be based on the pool whose elevators pay the highest price for the harvest as well as the cost of trucking the corn to the river. Beyond the inventorying of grain and the price-induced leakages of harvest in decision 5) above, this decision about the river location to which to deliver grain is the third source of flexibility in response to prices that we will measure as we estimate the elasticity of demand for navigation services. We will give the name "lock bypass" to this loss of distance shipped in response to congestion. Ultimately, if the system is extremely congested, delivery of grain to a point below the last lock might be economically justified, in which case the harvest is lost to the system and the lock bypass becomes a leakage.

These three sources of flexibility—storage until net delivered prices become more attractive, leakages to other modes or non-export uses, and lock bypass—constitute a complete catalog of short run options for a grain holder, which is the focus of this paper. In the analysis below we will try to find evidence that this flexibility is used to reduce the amount of grain shipping that is done when prices are elevated and to measure the extent to which high prices in any month cause shipping amounts to be reduced from a pool during that month.

It should be noted that we assume that grain shippers are fully rational in the sense of always attempting to choose the buyer who offers the highest price net of transportation costs. If a farmer has the sort of short run flexibility that this analysis is trying to find, it must mean that farmers have alternatives that become more attractive than river transportation in the short run when the price of river transportation rises. Clearly not all farmers will have alternative buyers for their crop in the short run. In effect, what we are doing in this analysis is trying to uncover how many shippers have alternatives that are sufficiently attractive that they can avoid paying high river prices in the short run by making alternative decisions for their crops.

The Identification Problem

If farmers have the sort of flexibility that will lead to an economizing on river transportation when it becomes difficult, then the demand for river transportation will be downward sloping. Thus higher prices will lead less to be shipped. However, when a simple correlation of monthly shipping prices and monthly shipping quantities is done, the opposite appears to be the case. These results are shown in Table 8 which shows the simple correlation between the monthly shipping price for any pool and the quantity shipped from the pool.

The logic of downward sloping demand curves appears to be contradicted by the results of Table 8. Two thirds of the correlations between price and quantity are positive and only one third are negative. The average simple correlation is positive. All correlations are small. For example, in the case of the positive correlation .2593 for Pool 30, price movements will explain only 7% of the shipping quantities. For most shipping pools, the explanatory power of price is considerably less.

The most logical explanation for the positive correlations in Table 8 is the identification problem. This problem arises because the shipping price is endogenous to the river system. With limited shipping capacity, high demands for grain will cause the demand for towboats and barges to rise, bidding up their price. Thus when demand is high, so will be the price of shipping. This phenomenon is illustrated in Figure 7 which show supply and demand curves for river transportation of corn.

In Figure 7, P represented the rate charged for shipping corn from a specific pool to the Gulf and Q represents the number of tons shipped in a month. S shows the supply relation, relating the price that towboat operators will ask for their services at any demand level. A demand shock—for example, lower ocean shipping charges at the Gulf—shifts the demand for grain to the right and causes more tons to be willingly offered to exporters in a month. This rightward shift of demand allows transporters the opportunity to get more for their services. All pools will be affected by the same demand shocks. Thus despite the fact that each pool is a small part of the entire grain export system and hence may be seen as price takers in the river transportation system, since the demand shock is felt by all pools, the price to each pool will adjust simultaneously.

Grain is only one commodity shipped on the river system. Our hope in beginning this study was that changes in the price of coal or fertilizer would lead to exogenous supply shocks that were larger than the shifts in the demand curve. Under these circumstances, instrumental variables techniques could be used to identify the demand curve. However, as noted previously, there is enormous seasonal variation in shipments from all pools, thus leading to demand shifts that dwarf supply movements. This precludes us from successfully identifying the demand for grain transportation using standard econometric methods.

The alternate approach, which is used in this paper, is to use a functional form that explicitly recognizes and controls for the volatility of demand. Demand for grain transportation depends on both the availability of grain to be exported and foreign purchasers' willingness to bid for the grain grown in the corn belt. Weather events that affect growing conditions will thus affect the demand for grain transportation, as will growing conditions in other parts of the world that grow crops that compete with American grain exports. There are also predictable seasonable supply shifts and predictable seasonal patterns to price movements.

In order to defeat the identification problem, we shifted our aim from predicting the level of corn shipments from a pool in a month on the basis of levels of prices and demand variables. We instead change our focus to predicting deviations from normal shipping levels on the basis of prices that are different from what would be expected from historical conditions. Our first model is:

$$Y_{ti} = a_i + b_i(p_{it}/meanp_i)(meanq_i) + c_i(Rivertons_t/Meanrivertons) + d_i(D_{it}) + e_i t \quad (1)$$

Where:

Y_{ti} is the excess (or deficiency) of corn shipments from pool i in month t beyond the amount predicted by the normal share of the current national corn harvest shipped from a pool in any month. The annual harvest for each year is assumed to be come in on October 1st. The crop year then extends from October 1st to September 30th of the next year. The dependent variable thus controls for demand shocks based on harvest.

p_{it} is the price for shipping a ton of corn from pool i in month t to the Gulf. It is calculated as the price to ship from St. Louis to the Gulf plus the time from pool i in time t to pool 30 divided by the time from the Twin Cities or Beardstown, IL multiplied by the difference between the Twin Cities or Illinois River price in time t and the St. Louis price at that time.

$meanp_i$ is the mean constructed price for all 144 months of our study from shipping from pool i to the Gulf.

$meanq_{it}$ is the average quantity shipped in the current month from pool i.

$Rivertons_t$ is the total tons of corn shipped to the gulf from all locations on the upper Mississippi, the Illinois, and Pool 30.

Meanrivertons is the average number of tons shipped during the current month from all three sources.

D_{it} is a dummy variable whose value is 1 if month t is later than the month at which a structural break is presumed to occur for pool i. Structural breaks are determined by cumulatively summing the dependent variable and finding the month within which the cumulative sum is a maximum or minimum.

e_{it} is an error term with assumed classical properties.

Equation 1 is designed to prevent the quantity variable from being influenced by seasonal and other predictable factors which lead to fluctuations in both transport prices and quantities. Only to the extent that prices are above their expected level are they expected to have an effect—an effect that is proportional to the normal level of shipments during the month at which the abnormal price is observed.

Demand shocks are proxied by the ratio of the total amount of corn transportation in a month from all pools relative to the monthly normal. We acknowledge that this variable is to some extent endogenous, but we could not discover a better variable to represent the worldwide demand fluctuations that dominate the data set.

The method for finding structural breaks will probably overestimate their importance. However, our preliminary analysis indicated that for some pools there were clear structural breaks and that ignoring them would force the data to attribute to included variables effects that were clearly not related to either price levels or external shocks.

Results

Table 9 shows the results of the estimation of the model for all pools with sufficient observations to successfully fit a model. Standard errors and t statistics for the coefficient estimates are presented in Table 10.

Each table is divided into three sections. Pools numbered 3-29 are on the locked portion of the Upper Mississippi River. Those numbered 102-109 are on the Illinois River. Pool 30 is on the free-flowing part of the Upper Mississippi below St. Louis. It is logical to assume that shipments from pool 30 will respond differently to the cost of shipping on the waterway system from other pools since high shipping prices may cause some shippers to bypass the lock system entirely and deliver corn directly to Pool 30.

The overall fit of most pools in Table 9 is significant at the 1% level or better. The R-square column shows that, while there are some pools whose shipping patterns the model can not explain, for most pools there is a respectable explanatory power of the three independent variables of between 20 and 60%.

The reader will note that all demand estimations for pools on the locked portion of the Upper Mississippi were estimated with 101 observations. This is the result of the method that we used for inferring shipping prices for each pool, which prorates the spread between Twin Cities and St. Louis shipping prices by the shipping time to St. Louis from any pool relative to the Twin Cities-St. Louis time. Thus we could only calculate shipping prices for a pool if there was a shipping price recorded for the Twin Cities in that month. Thus, despite the fact that the shipping season is longer for some Mid-Mississippi pools, all observations were eliminated if the Upper Mississippi was closed at the Twin Cities. This problem did not occur on the Illinois except at the pool closest to Chicago, where only 129 months of observations were available due to the lack of movements in some winter months.

The strongest effect is that associated with the structural break dummy variable. For all pools except pool 28, there appears to be a year and month after which there was a distinct break in the level of corn shipments out of a pool that can not be explained by the other included variables. Recalling the earlier discussion, our technique has been to find a year and month that corresponds to a maximum or minimum of the sum of deviations from the normal share of the national corn harvest shipped from a pool. The year and month after which this dummy variable has a value of are given in columns 8 and 9.

The structural break dummy variables are intended to cover such factors as the opening of an ethanol plant or other local corn processor or the establishment of a new rail shuttle service that allows the grain merchant to market local corn without delivering the product to the local pool. Intermittent shuttle services that only exist when the price of river transportation is high do not constitute a structural break since their effect should be taken into account by the price term in the equation. It is also possible that new elevator capacity will be located on a pool, that local processing plants will close, or that a new shuttle service will terminate in a pool, thus causing the structural break to increase corn shipments from a pool.

Table 9 shows that the majority of the effects associated with these structural breaks are to reduce the amount of corn shipped from a pool. While there is a substantial number of positive dummy variable coefficients, these numbers are almost always small. The major exception is pool 30, in which the months after April 1998 had 103167 more tons shipped than before that month, beyond what would be expected based on other factors. But pool 30 can be presumed to be the beneficiary of shuttle trains designed to bypass the lock system, so this coefficient is not an anomaly.

Summing over all pools in the locked part of the Upper Mississippi, the combined effect at the end of all structural shifts is to reduce total shipments by 414,190 tons per month. Similarly, on the Illinois River, the combined effect of all structural shifts was to reduce movements by 146,901 tons per month below what they would have been had the structural shifts not taken place. Structural shift parameters for the pools with the largest shipping volumes are uniformly negative, suggesting that at the largest pools, shippers were taking advantage of opportunities to bypass the river system that were not available at the beginning of the period.

The second strongest effects in Table 9 are those associated with demand shocks to the system. These are recorded as the system-wide shipments in any month divided by what the normal level of shipments would be in any month based on the pool's monthly share of the annual corn harvest in the current crop year. These coefficients are uniformly positive and significant for all pools except 3, 28, and 29. The coefficient measures the number of extra tons that would be expected to be shipped from a pool in a month if the total river shipments in that month were 100% larger than they normally would be. Not surprisingly, the very largest pools, numbered 4 and 107, have the largest coefficients. This coefficient should reflect the capacity at a pool, and thus the extent to which demand shocks can be accommodated by increases in any pool. Since capacity closely mirrors actual shipments, the numbers in column 3 closely track the size of shipments from a pool.

The most interesting numbers in Table 9 are those in column 5 which show the price effects on shipping patterns. These are the coefficients on a variable that interacts the ratio of the price in any month to the price that we would normally expect in any month with the expected shipping levels in any month based on the pool and month's share of the corn harvest in the current crop year. The interaction is necessary since pool shipments are seasonal and strongly affected by harvest and since the dependent variable is measured in tonnage terms. All but three of these price coefficients are negative, and thus consistent with downward sloping demand curves. As previously noted, the expected coefficient on price for pool 30 is logically different from those for other pools, since to the extent that high prices cause bypass of the lock system, those tons may appear in pool 30, which is below the last lock of the system. The positive coefficient on price at lock 30 is not significantly different from zero, suggesting that increased shipments due to bypass were offset by decreased shipments on the river that would normally be expected as a means of economizing on river transportation when its cost is high. These positive but insignificant coefficients are also seen at the two pools immediately upstream from pool 30.

For all other pools, the price effects are negative, and for many of them statistically significantly so. These effects appear to be especially strong for the largest pools, Pool 4 and Pool 107. The coefficient values are roughly elasticities. They represent the number of additional tons that would be expected to be shipped from a pool in a month if the price variable were 1 unit higher. Since this variable is interacted with normal quantity in a month, it can be read as a multiplier of normal tons. Thus, for example, with a coefficient on the price variable for pool 4, in a month that would normally see 300,000 tons of corn shipped, a doubling of shipping prices would cause .066*300,000 or 19,800 fewer tons to be shipped than would be expected based on the demand shock and structural break variables. Extrapolating to an extreme case, a 100 percent increase in shipping prices in a month above what is normal for that month, would cause about a 6.6% decrease in shipping volumes below what would otherwise be expected. This effect is statistically significant for the largest pools and for many others.

The elasticity of corn shipments with respect to shipping price shown in column 5 of ranges from -.02 to -.35. It is likely no accident that the lowest elasticities occur at or near St. Louis. The average coefficient in the seven highest pools on the Upper Mississippi (pools 3-15) in column 5 of Table 9 is -.012 while the average for the lowest 7 pool (pools 23-30) is -.035. In neither case, however, are these elasticities close to the elastic range, suggesting that effects other than shipping prices are more important in determining the quantity of corn shipped from a pool. There nonetheless does seem to be some degree of economizing on shipping that results from higher shipping prices.

In the previous section we noted that there were three logical sources of such economizing during periods of high shipping prices in the short-to-intermediate run that these data allow us to observe: 1) transfers of shipments to lower pools to bypass congested locks; 2) leakages from the river system; 3) increasing inventories during high price periods in anticipation of lower priced periods in the future. Attempts to directly identify bypass of locks during periods of unusually high shipping prices were unsuccessful. Pools have vastly different shipping capacities and shipping quantities that vary by a factor of ten or more. Regressions that included as regressors price interaction terms for upstream as well as the current pool showed signs of multicollinearity, with diminished significance for all coefficients. While it is logical to assume that there exist shippers near the boundary between the hinterlands of different pools who will make decisions to access the river farther south when shipping prices are high, this study was unable to find direct evidence of such behavior.

This study did, however, investigate the role that inventories play in buffering shipping decisions in response to relatively high and low prices for shipping. These results are discussed in the next section.

Inclusion of inventory buffering for shipping decisions

When shipping costs are unusually high, if storage capacity is available, it may be possible to increase the normal level of inventories to economize on shipping costs. This decision may be forced by market conditions if high shipping prices mean that it is impossible to deliver corn to the Gulf at a profit, obliging the owner of the commodity to hold it for a time when market conditions are more favorable.

We have no direct measure of inventory levels at each pool, nor do we have measures of the storage in geographic areas that typically ship corn to each pool. To introduce inventory holding into the analysis it is necessary to construct inventory levels from the information that is available. This is done in a two stage process. In the first stage, inventory in any month is calculated as the accumulated dependent variables over the data set. This represents the sum of abnormally high or abnormally low shipments from any pool in each month where normal is assumed to be the pool's average monthly share of the current crop year harvest of corn. This variable was used previously to identify structural breaks.

In the first stage, these abnormal inventory accumulations are used as a regressor, both independently and interacted with price. From these first stage regressions, we then find a residual of inventory accumulation not accounted for by seasonality, crop year harvest, or any of the independent variables of the regression. In the second stage, inventory levels are recalculated as the accumulated sum of all error terms up to the year and month for the observation. Inventory is measured in the way up to an additive constant. Thus negative inventory accumulations should be understood as inventory levels that are below historical trends.

It should be noted that this measure of inventory accumulation is highly imperfect, not only because of measurement issues, but more particularly because it assumes that if the normal amount of grain is not shipped in a month that remains in storage to be shipped at a later period. In fact, of course, it may be moved out of a pool by an alternate mode of transportation, it may be allowed to spoil, or it may be used locally, for example in milling, feeding, or processing. Nonetheless, we believe that inventory levels may be roughly approximated in the way we have done; it is likely, however, that the fluctuations in inventory levels calculated in this way are somewhat exaggerated, producing highs that are too high and lows that are too low.

Second stage regressions have the same dependent variable as the previously reported results—namely the tons of corn shipments from a pool in any month that are above or below the shipments that would be expected by applying the pool's average monthly share of total corn harvest to the current crop year's harvest. The independent variables include the same structural break dummy that was discussed earlier as well as the demand shifter, total river tons as a proportion of what the monthly normal river tons are for that month. The price variable enters as it does before.

In addition to these variables, the second stage regressions now include our constructed inventory levels and the interaction of price and inventory. The logic is that higher than normal inventory levels should lead to higher than normal shipments as the cost of storage encourages shippers to move uncomfortably high inventory levels downstream. However, the rate at which excess inventory is moved out of storage depends on cost of moving the grain downstream. Our expectation is that abnormally high prices will cause the rate of inventory drawdown to be slower than it otherwise would be. Thus a positive coefficient is expected on inventory levels and a negative coefficient is expected on the interaction of inventory and prices.

The results of these second stage regressions are shown in Table 11. Standard errors and t statistics for these results are shown in Table 12. The coefficients for the variables that were included in Table 11 are quite similar to those in Table 9, with the same patterns noted previously. The size of structural break dummies are roughly the same as are the effect of demand shocks. Presumably because price enters twice in Table 11, once interacted with normal quantity and once interacted with inventory, the independent effect of the price-normal quantity interaction is less statistically significant than previously.

The imprecision of our constructed inventory measure is reflected in the frequent insignificance of the inventory variable in our regressions. The most common sign of the coefficient on constructed inventory is positive, and it is most common to find a negative interactive price/inventory effect on quantity when there is a positive sign on inventory. In almost all cases the signs of the inventory and inventory-price interaction terms are opposite, suggesting that high prices dampen the independent effect of inventory levels.

Since the price variable, before interaction, is normalized to 1 by dividing by the normal price for that month, the sum of the inventory coefficient and the interaction of the inventory coefficient and 1 show the marginal effect of a 1 ton increase in inventories, if shipping prices are normal. This effect is uniformly positive, meaning that if shipping prices are held fixed at their average level, an increase in inventories will lead to an increase in shipping out of a pool. The combined effect ranges from .001 tons to .333 tons.

If inventories are at their normal level, the elasticity of shipments on shipping prices can be read directly from the coefficient on the price-normal quantity interaction term. These effects are almost all negative, and especially so for the pools with the largest shipping quantities.

If inventories are above normal by an amount equal to the normal amount that is shipped in a month, the sum of the two price interaction terms represents the elasticity of shipments with respect to shipping prices with very high inventory levels. These combined effects are almost always negative, but the imprecision of our inventory measurement methods introduces more measurement error into these terms than we had seen in previous regressions.

It has been noted previously that the construction of the inventory variable is based on the assumption that shipments not made during any month are retained in inventory.

Thus, unusually high inventories in one month would be gradually released to river shippers in the form of higher shipments in the future. This is, of course, incorrect, since some part of the harvest will be diverted to other locations or other uses than exports. If all of the grain is retained in storage and released according to the coefficients in Table 11, eventually all of the cumulative deviations from normal will disappear. However, in the presence of storage capacity limitations, following the incentives of the price system, some unknown proportion of total shipments will be released to non-export uses as well.

An Alternative Way of Measuring the Effect of Inventories

The effects of an alternative way of measuring inventory accumulation are shown in Table 14. In this approach, inventory accumulation is associated with shipments in a previous month that are below normal and inventory draw-downs are measured as the extent to which shipments in the previous month are above historical levels based on a pool's average monthly share for any month of the current crop year. The advantage of this method is that no assumption is made that unshipped corn is retained in inventory rather than being released to other sectors or other destinations. The disadvantage is that it assumes that inventories are retained at most one month, after which they are shipped or released to other sectors or destinations.

Following the discussion in the previous section, an unusual inventory accumulation should increase the quantity shipped from a pool in a month, above that indicated by normal shipping patterns, prices, and demand conditions. Thus a positive coefficient on inventory increment is expected. However, higher prices for shipping on the river should slow this effect, and thus the coefficient on the interaction of prices and inventory increments should be negative.

Table 13 does not bear out this expectation. While it is interesting to note that in most cases the signs on the inventory term and the interaction of price and inventory are opposite, there are many more negative signs on inventory increment than there are positive signs. We take this as an indication that there is an autoregressive process that has not been completely accounted for by the demand shock regressor. That is, unexpectedly high shipments in one month predict unexpectedly high shipments the following month, perhaps due to slow moving market conditions or perhaps due to filling of export contracts over several months rather than one.

The price effects are almost uniformly insignificant. There are no examples of positive coefficients on inventory increments being reinforced by positive coefficients on a price-inventory interaction. Price effects in general soften the direct effect of inventory accumulation in the previous period, with higher prices being associated with a smaller combined direct and interaction effects of higher inventory levels. When the coefficient on inventory accumulation seems to indicated month-to-month inertia in shipping patterns, higher shipping prices are associated with a more rapid return of this inertia to normal conditions.

It is interesting to note that the direct price effect, through interaction with normal shipping levels in any month, remain negative. As in Table 11, however, when price enters interactively in two different variables, the statistical significance of price coefficient is reduced. It is still the case, however, that the strongest negative coefficients on price are with the largest pools, and that the price coefficient for Pool 30 is positive, in accordance with our theory.

Discussion

We have been gratified to find that a change in the price of river shipping has a measurable effect on the amount of river shipping of corn. The direction of the effect is in accordance with the slope of a demand curve. The size of this effect is not large, however. We find that the short-to-intermediate term demands are quite inelastic with price sensitivities at the low end of the inelastic range.

We are not surprised to discover that the demand elasticities in the short-to-medium run are quite small since in the short run the degree of flexibility that grain producer has is quite limited. This paper has noted three flexibilities when the price of river transportation is unusually high: 1) to store the grain and wait until shipping prices drop; 2) to bypass the local pool and, at the expense of higher truck transportation, to deliver grain to a lower lock on the system; and 3) to divert the grain to a non-river destination. In our analysis, we can not distinguish between grain that disappears from the river because it is used locally to feed hogs or make ethanol, or grain that is loaded on a train for delivery to the Pacific Northwest or the other non-Gulf ports.

It seems clear from the results of this exercise that some of these flexibilities are used and that there is a clear responsiveness to shipping decisions to the price of river transportation. However, it seems very unlikely that in the short-to-intermediate run that there would be a great deal of flexibility of shipping decisions in response to prices. In particular:

1) Storage capacity is not unlimited. This may, in fact, be the reason for the results of several pools that showed that high shipping prices caused acceleration of grain shipments out of inventory. When the demand for river movements is high, and thus the

price of river transportation is high, there may be a diminished ability to buffer high prices for river shipment by holding inventories. In a sense, in the presence of limited storage capacity, high inventories must be moved regardless of price. The assumption that high prices can be buffered by inventory holding assumes that there is unlimited and inexpensive storage capacity in each pool and neither assumption may be true.

2) In addition to storage capacity, there is limited loading capacity and relatively few pools have loading capacity that can be accessed at peak periods. Pools that have excess loading capacity at peak periods may be farther apart that is generally assumed. Thus trucking grain to the next pool with available loading capacity may require more truck transportation than we have assumed. Since truck transportation is relatively expensive per mile in comparison to barge transport, in the presence of insufficient free capacity, lock bypass may require longer distances of high cost transport than has been assumed.

3) The reasoning suggesting short run flexibility to shipping prices is based on the assumption that a farmer can get a higher price for grain by delivering it to a local processor, feed lot, or rail head. But there are capacity limitations in each of these outlets as well—an ethanol plant may not be able to rapidly increase production in response to cheap grain. To use extra grain, a feed lot will need to get extra cattle, which can not be done in the short run time-frame assumed by the model. Similarly, railroads may need to get extra cars, equipment, and crew to handle the extra grain that appears at its loading facilities unexpectedly, but which may disappear tomorrow if the price of river shipping drops again. It is unlikely that a railroad will be willing to handle such transient traffic as is assumed by a model that produces high short run flexibilities to high river shipping prices.

All three of these considerations explaining the low short run flexibility of river shipping to the price of river shipment are based on capacity limitations in one part or another of the transportation or processing sectors. But the structural changes that dominate the explanatory power of the regressions in Tables 9, 11, and 13 are similarly motivated by discreet changes in capacities. For example, there appears to have been a one time change in the Spring of 1996 that caused fewer tons of corn to have been shipped after that date from the middle Illinois River. The natural assumption is that a shuttle train was established after this date or new capacity was added for local processing of corn which allowed farmers to sell their product to a non-river location. Which ever assumption is correct, after the new capacity was put in place, there was a reduced usage of river services that was unrelated to the price charged for shipping corn to the gulf after that date.

It cannot be emphasized too strongly that while these capacity increments are treated as exogenous shifters of the demand curve in the short run demand estimations that we have done here, they may be based on assumptions about future prices for shipping on the river system. If investors believe, for example, that river transportation prices will be higher in the future, they may be willing to invest in an ethanol plant near the river since they will be able to get raw materials relatively cheaply. Or a railroad may be willing to establish a new shuttle service when the price of river services is high, but not if prices are expected to fall in the future. In other words, movements of prices on the river affect transportation demand primarily not through contemporaneous economizing on the use of river services but through changing the expectations about the profitability of making investments that will draw commodities away from being shipped on the river system.

The modeling of expectations has long been a challenge that has stumped economic forecasters. Thus there is no reason to believe that we can successfully use, for example, lagged values of prices of river services to forecast the installation of capacity increments in local transportation facilities or corn processing facilities that compete with river for the annual harvest.   In our case, however, there is a further issue that makes it implausible that river shipping prices can be used to predict capacity increments—namely, that the real price of using the river is essentially unchanged over the 12 years of the study. As noted in previous sections, there is a strong seasonal pattern to the price of shipping corn to the gulf with insignificant trends on the locked section of the river and a significant annual decline in the real price of river transportation below St. Louis.   Once the seasonal pattern of price movements is purged from the data, the remaining price movement are not nearly large enough to inform a change in expectations that would allow us to relate capacity increments to changes in expected transportation prices, much less the location of such projects.

Conclusion

The results of this investigation have shown that there is some short run flexibility that is used by purchasers of grain transportation to economize on the use of river services when shipping rates are high. Evidence of such flexibility was not easy to find, however. This was the result of several factors, most notably the vastly greater shifts in demand for river services over the 144 months of this study than shifts in supply, leading to difficulty in identifying the demand curve. The supply of river services has been quite stable over the period. While there is considerable fluctuations in the price of transporting grain to the gulf, almost all of this variation is seasonal in nature. With little change in real prices over the period, and with only small shifts in the supply of river services, direct methods for measuring the demand curve turned out to be impossible.

Using a method that focuses on deviations of prices and quantities from normal rather than the levels of each variable, we were able to find a robust inverse relationship between shipping prices and the amount of corn shipped from each pool. The exception to this rule is Pool 30, the free-flowing part of the Mississippi below the last lock on the system which has a positive relationship between shipping prices and shipping quantities—the result, we believe, of lock bypass during congested periods. In general, the farther from St. Louis a pool is, the higher the elasticity of demand.

None of the elasticities measured is near the elastic range, with elasticities commonly measured to be below .1. This indicates that while there is short term flexibility to deal with high prices of river shipping, there is not a great deal of flexibility. We believe that this does reflect the true situation. Capacity constraints both on transportation systems as well as feed lots and corn processors like ethanol plants limit the ability of a farmer to find ample attractive alternatives at periods of high shipping prices to the Gulf. Since our unit of observation is monthly shipments of corn from a pool and our prices are quoted for shipments in that month, what we measure is short run elasticities of demand. It is apparent that these elasticities are not high.

While in the short run, capacity limitations of the river system, the rail system, and competing demanders for the corn harvest can be taken as fixed variables, independent of the price of shipping, the same is clearly not true in the long run. One of the most striking results of our estimations is the importance of the effects of variables that track structural shifts in demands at different pools. We believe that these structural shifts primarily reflect the installation or removal of loading capacity on the river and capacity increments added by alternative modes and alternative demanders of corn. In our estimation, we have treated these structural shifts as exogenous events. We believe, but can not prove given our data, that these capacity decisions respond to expected long term trends in the prices charged for river transportation, with higher shipping charges to the Gulf reflected in an accelerated program for adding capacity by alternative modes and users of corn. If this is the case, the long-run elasticities for the movement of corn on the Mississippi and Illinois Rivers will be considerably higher than the very low numbers that we measured for short run demand elasticities in this study.

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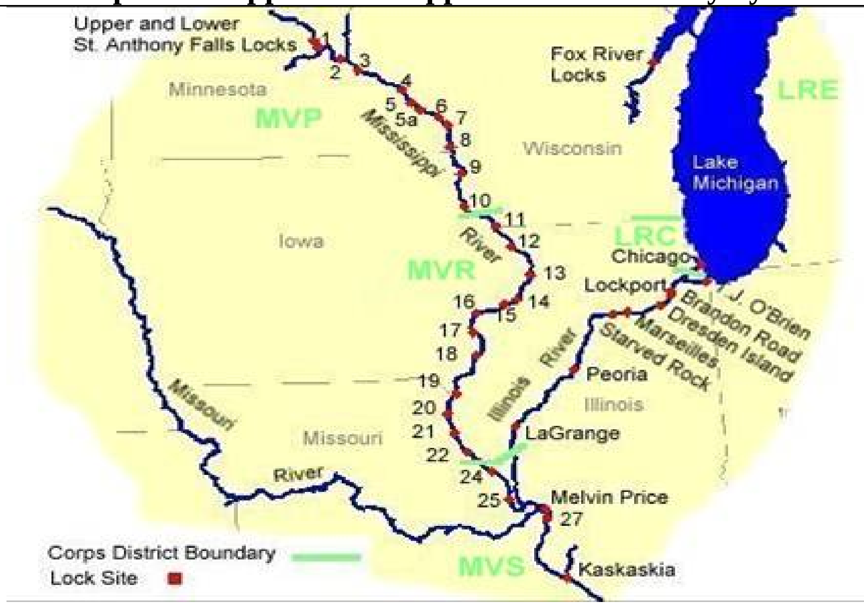
Figure 1
A Map of the Upper Mississippi/Illinois Waterway System



Source: US Army Corps of Engineers

Figure 2
Monthly Tons of Corn Shipped from Pools 3-29, 1991-2002

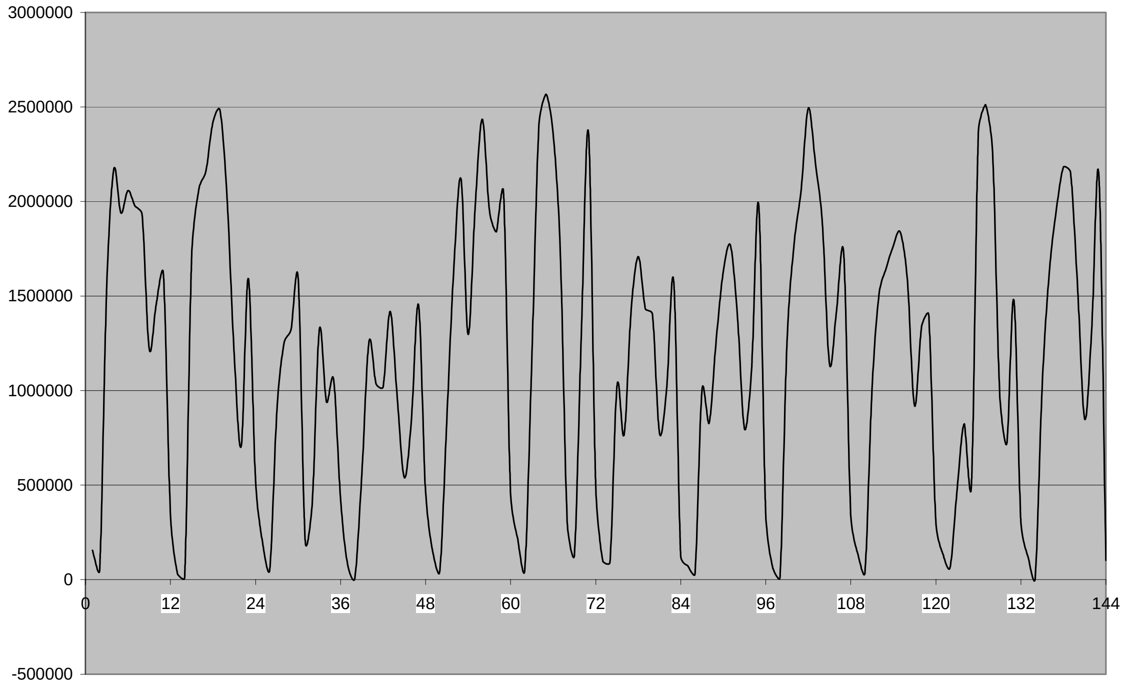


Figure 3

Monthly Corn Tonnages Shipped from Illinois River Pools and Pool 30 1991-2002

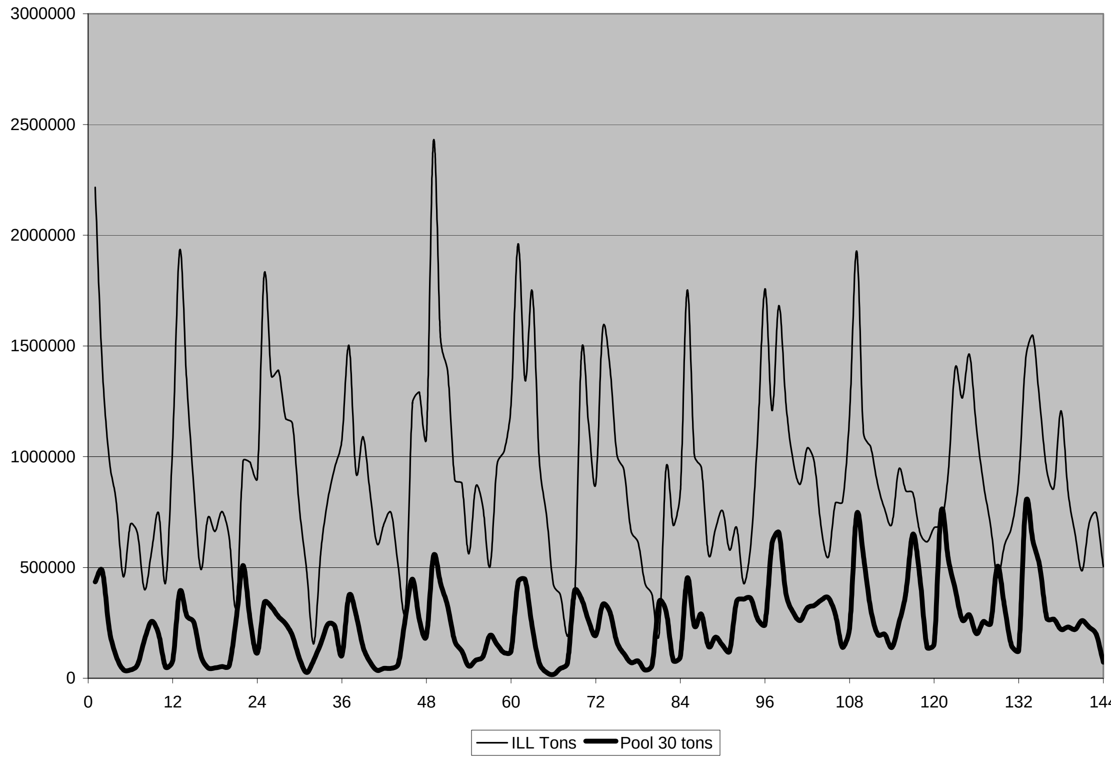


Figure 4

Real Price to Ship a ton of Corn to the Gulf from Three Locations 1991-2002

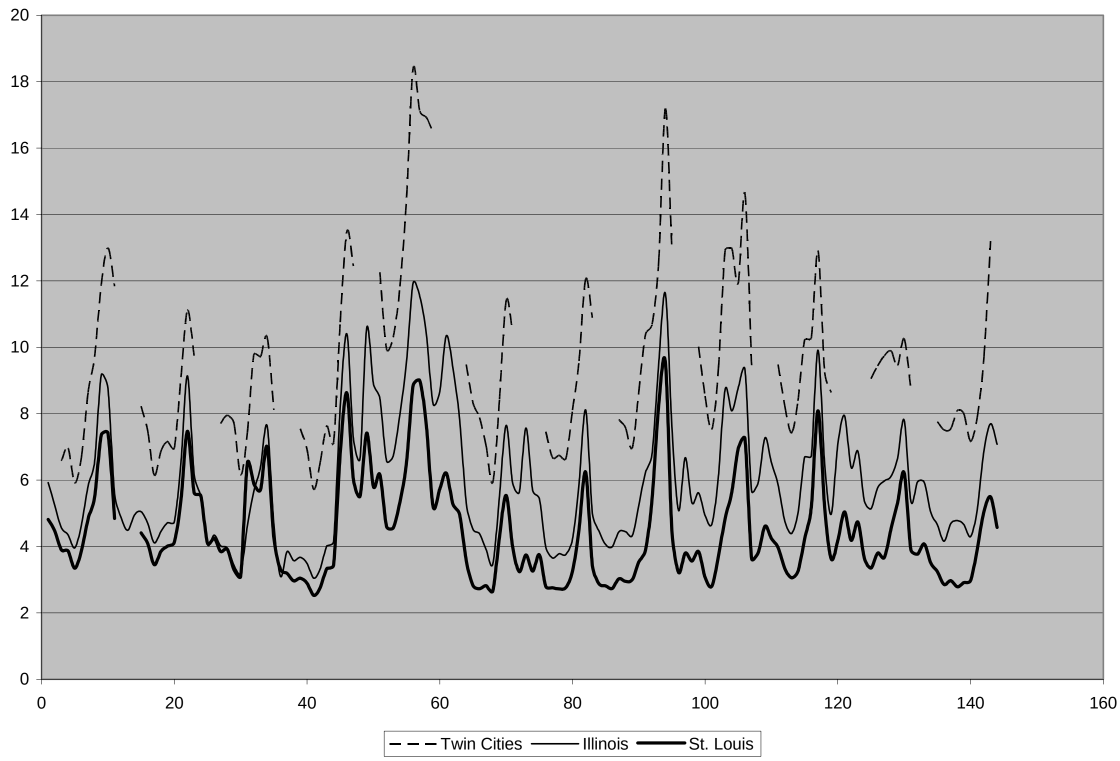


Figure 5

Gulf and Pacific Northwest Ocean Rates to Asia, 1991-2002

Figure 6

Real Ocean Spread and Spread as multiple of St. Louis Real Rate

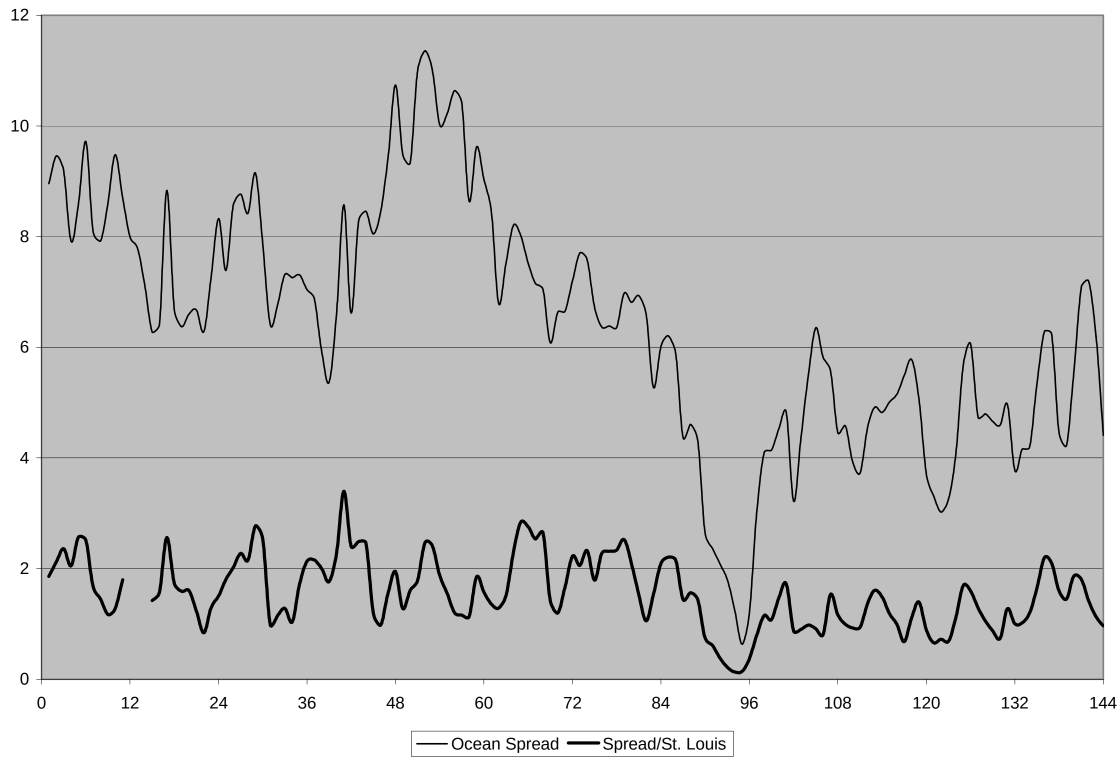


Figure 7

A Demand Shock to the River Transportation System

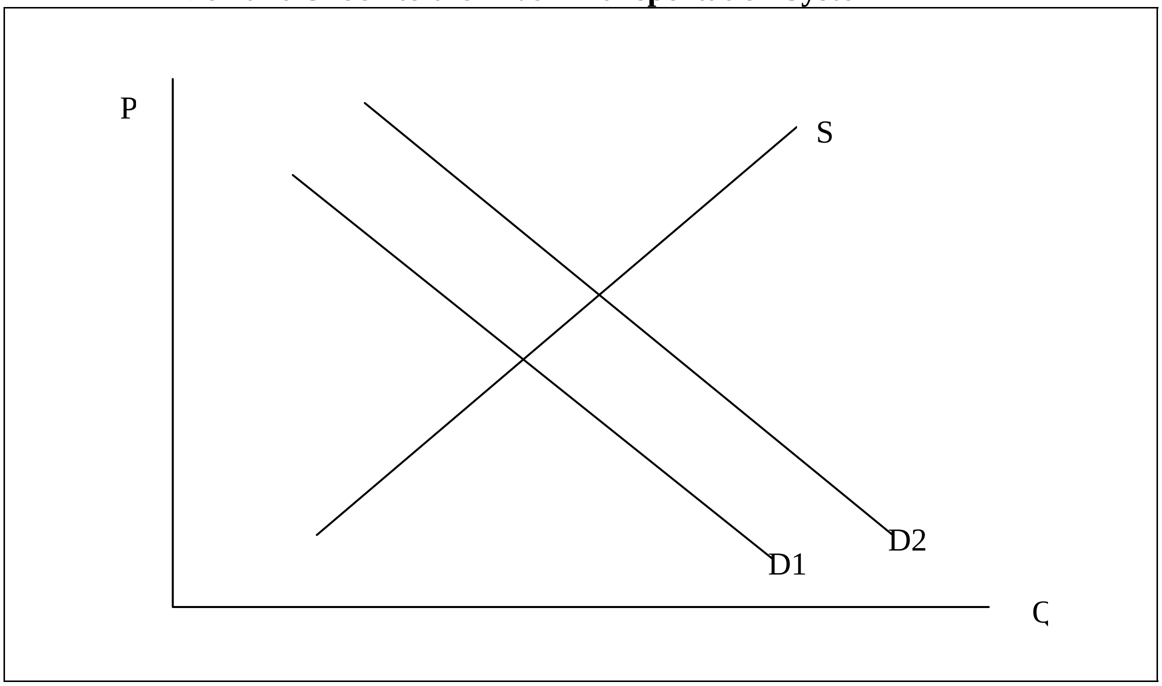


Table 1
Definition of Pools by Lock and River Mile

Pool Number	Lock at bottom of pool	Low river mile from Cairo
3	2	815.2
4	3	796.9
5	4	752.8
6	5	738.1
7	5A	728.5
8	6	714.3
9	7	702.5
10	8	679.2
11	9	647.9
12	10	615.1
13	11	583.0
14	12	556.7
15	13	522.5
16	14	493.0
17	14	493.0
18	15	482.9
19	15	482.9
20	16	457.2
21	17	437.1
22	18	410.5
23	19	364.3
24	20	343.2
25	21	324.9
26	22	301.2
27	25	241.4
28	Melvin Price	200.8
29	27	185.5
30	Cairo-St. Louis	0.0
102	Lockport	1106.3
103	Brandon Road	1101.2
104	Dresden Island	1086.7
105	Marseilles	1059.8
106	Starved Rock	1046.2
107	Peoria	972.9
108	Lagrange	895.4

Table 2
Monthly Corn Shipments from Pools, 1991-2002

Pool number	Number of months in which corn shipments were made	Mean monthly shipments from pool	Mean monthly shipments from pool 1991-1992	Mean monthly shipments from pool 2001-20022
3	56	23404		20210
4	122	303638	346830	358602
5	4	3650	3650	
6	105	43889	24865	58992
7	1	1426		
9	126	144422	136134	142111
11	109	26511	15945	24095
12	1	1600		
13	123	160850	194953	173674
14	2	1666	1786	
15	129	123625	216173	91823
16	120	35886	54304	30580
17	134	167141	228204	110777
18	133	25972	15582	28912
19	134	47675	68140	64288
20	125	27784	37958	24237
21	132	43818	43019	56326
22	137	80983	94177	99267
23	126	23317	15420	35937
24	127	13034	10459	19919
25	125	15984	13111	23680
26	118	13665	9949	23291
27	3	2057		2336
28	107	5699	6015	5432
29	51	6085		5616
30	144	245961	187858	330231
102	142	32757	44615	23093
103	5	1878	2351	1578
104	2	2333		2333
105	143	111099	90554	123709
106	144	89600	90154	88366
107	144	381482	353689	359763
108	144	213812	193467	211093
109	144	103107	102308	120852

Table 3

Average Monthly Tons of Corn Shipped from Mississippi and Illinois Pools 1991-2002

Pool	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3			1400	14666	32542	38359	25231	28569	11606	14422	23361	
4	5224	5175	83599	306316	438498	537336	521284	460630	278232	260769	223551	10762
6	5566		9988	37132	55835	70330	65709	46869	24674	36680	48072	4117
9	4462	4109	45046	122844	183118	242348	251154	170455	111841	166622	216605	14258
11	1879		15338	24134	24229	28420	31705	23498	14807	24789	59166	2926
13	6356		101888	209922	215575	244128	221966	183053	112770	117220	229874	13854
15	4195	1560	137300	209966	197252	190226	163408	113812	85029	52775	158954	28034
16	6754		29301	32699	44312	47952	51025	32870	20170	36385	63526	9457
17	20749	14634	201727	225447	202826	215451	211891	199157	114297	132041	254781	92053
18	8207	3009	35956	29208	27863	30174	33211	28730	17389	31082	37863	12509
19	12865	1936	75839	69474	61612	58727	50943	48548	31930	27792	73119	24613
20	7212	3453	36180	32731	30127	30653	31684	24737	17993	16272	41948	31247
21	4880	3822	65785	52961	44440	52478	57892	47298	33560	40620	56630	30134
22	22048	13164	135822	113915	83362	95722	75158	67149	52551	79245	120910	73186
23	8186	3498	29523	26877	22108	18802	15795	18527	20559	44077	39088	14257
24	5782	6743	19201	12292	8150	9981	9283	10151	11691	21130	20419	14955
25	6979	6843	21778	13741	12955	11952	10617	9011	26213	33466	18159	10475
26	5706	10337	17900	10510	9245	5992	10465	15747	20735	28841	13570	4990
28	6385	4555	5617	3093	2081	2907	1880	3407	7234	13477	7123	1507
29	7626	8684	8728	4132	3488	6182	5400	6808	4677	5238	4609	6808
30	516729	428866	291323	169636	144045	115617	127722	179002	335150	321490	179105	142845
102	58412	39368	58630	47884	28932	23940	23523	24574	8954	11145	31681	33373
105	206343	146747	143002	111359	91368	93084	94229	63206	41201	65203	119903	153549
106	153333	118165	98829	93071	88272	89594	85369	58921	30537	53900	98058	107156
107	690372	516665	495807	396934	379386	369970	336497	247697	136734	216745	317447	473534
108	433274	343160	269217	166671	160840	126939	112129	106569	135019	319328	210587	182007
109	164295	135326	129569	78203	73038	66767	58336	54189	112737	210303	94324	60202

Table 4

Seasonality and trend regressions, for corn shipments from three regions, 1991-2002

	Mississippi Tons		Illinois Tons		Pool 30 Tons	
misstons	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
trend	-276	881.4	123	542.3	1427	189.9
Jan	-1691385	178944.3	996798	110098.0	397569	38546.8
Feb	-1772475	178920.5	590237	110083.3	308280	38541.7
Mar	-764833	178900.9	485462	110071.3	169309	38537.5
Apr	-299117	178885.7	184408	110062.0	46195	38534.2
May	-142746	178874.9	111999	110055.3	19177	38531.8
Jun	99282	178868.3	60458	110051.3	-10678	38530.4
Constant	1829638	141902.4	701126	87307.5	23550	30567.5
Aug	-300052	178868.3	-161961	110051.3	49853	38530.4
Sep	-823407	178874.9	-245765	110055.3	204574	38531.8
Oct	-636416	178885.7	166298	110062.0	189487	38534.2
Nov	-105857	178900.9	161428	110071.3	45675	38537.5
Dec	-1459625	178920.5	299124	110083.3	7988	38541.7
R-square	0.69		0.62		0.70	
Number of observations	144		144		144	

Table 5

Sailing hours to Pool 30

Pool	Mean	Std. Dev.	Min	Max
2	159.4	9.7	136.7	182.2
3	158.8	9.6	136.1	181.6
4	157.7	9.6	135.1	180.5
5	146.7	9.7	119.8	168.6
6	146.7	9.7	119.8	168.6
7	138.0	9.4	112.0	159.1
8	134.1	9.3	108.2	154.7
9	131.1	9.1	105.3	151.4
10	127.0	9.1	102.2	147.0
11	123.2	9.1	98.9	143.1
12	116.7	8.8	93.6	135.9
13	109.9	8.5	87.6	128.8
14	102.6	8.3	82.3	121.7
15	95.8	8.1	76.0	114.6
16	89.3	7.8	70.6	108.0
17	82.0	7.5	63.6	100.4
18	74.5	6.9	57.9	93.1
19	70.5	6.4	55.2	88.5
20	64.4	5.9	50.6	81.6
21	59.0	5.4	46.4	75.0
22	52.6	5.1	39.4	67.5
23	44.0	5.0	29.4	58.7
24	38.3	4.7	26.5	52.2
25	32.7	4.4	23.7	45.3
26	25.5	2.9	19.5	33.0
27	17.9	1.6	14.5	22.0
28	10.2	0.7	8.7	12.2
29	3.4	0.3	2.8	5.1
102	82.0	7.3	69.1	101.3
103	69.7	6.3	57.8	87.8
104	66.3	6.2	55.3	83.9
105	61.8	6.1	51.4	78.7
106	54.1	5.8	45.0	71.0
107	49.5	5.6	41.5	65.8
108	35.6	4.0	29.6	48.6
109	19.8	1.3	17.0	24.1

Table 6

Trend and seasonality in transit time from three pools to pool 30

	Pool 4		Pool 13		Pool 107	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
trend	0.073	0.018	0.062	0.015	0.040	0.009
Jan	(dropped)		(dropped)		5.73	1.80
Feb	(dropped)		(dropped)		1.27	1.80
Mar	-19.74	3.68	-16.70	2.80	-1.42	1.80
Apr	-13.77	3.25	-9.91	2.79	-2.66	1.80
May	-10.86	3.18	-8.18	2.73	-3.11	1.80
Jun	-5.84	3.18	-4.67	2.73	-3.70	1.80
Constant	159.70	2.69	111.87	2.29	45.59	1.43
Aug	-0.44	3.17	-0.23	2.73	2.19	1.84
Sep	-7.48	3.17	-6.92	2.73	2.79	1.80
Oct	-5.76	3.17	-4.64	2.73	2.56	1.80
Nov	-7.01	3.17	-4.61	2.73	2.35	1.80
Dec	(dropped)		-17.34	3.83	6.73	1.80
R-square	0.43		0.47		0.43	
Number of observations	101		109		143	

Table 7

Trend and Seasonality Regressions, Three Rate Series, 1991-2002

	Twin Cities		Illinois		St. Louis	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
trend	0.003751	0.005379	0.003941	0.003333	-0.00705	0.002286
Jan	-0.74201	2.399178	0.855626	0.676611	0.326816	0.463496
Feb	(dropped)		0.068243	0.676521	-0.1743	0.463489
Mar	-0.55507	1.004543	-0.1729	0.676447	-0.14955	0.453393
Apr	-1.16003	0.950517	-1.04574	0.67639	-0.75072	0.453353
May	-1.74509	0.928754	-1.33081	0.676349	-1.04673	0.453324
Jun	-1.13919	0.928708	-0.83239	0.676324	-0.74909	0.453307
Constant	8.917537	0.765138	5.437144	0.536551	4.708766	0.361361
Aug	0.55392	0.928708	0.328687	0.676324	0.597308	0.453307
Sep	1.747849	0.928754	2.032562	0.676349	2.117729	0.453324
Oct	3.236096	0.928832	2.943764	0.67639	2.754385	0.453353
Nov	1.866561	0.928941	0.442636	0.676447	0.373813	0.453393
Dec	(dropped)		0.089478	0.676521	0.041277	0.46417
R-square	0.3593		0.3614		0.5283	
Number of observations	105		144		141	

Table 8

Table of Correlations between price and quantity

Pool	Simple correlation coefficient between monthly tons and monthly river shipping price
3	-0.2234
4	-0.1207
6	0.135
9	0.179
11	0.3233
13	0.033
15	-0.2245
16	0.0988
17	0.1115
18	0.1814
19	-0.1492
20	-0.1823
21	-0.0237
22	-0.0282
23	0.169
24	0.0684
25	0.2952
26	0.3146
28	0.4536
29	-0.0219
30	0.2593
102	-0.2602
105	0.0514
106	0.0538
107	0.0285
108	0.3012
109	0.3982

Table 9

Regression Results for Simplest Structural Model

Pool num. (1)	Constant (2)	Structural break dummy (3)	River tons/ normal (4)	(Price/ normal price)*normal tons (5)	R-square (6)	num of observ (7)	Year of trend break (8)	Month of trend break (9)
3	-4627	-8020	6468	-0.039	0.065	101	2001	10
4	-180242	-141018	382730	-0.234	0.481	101	1992	9
6	-44356	15446	35825	-0.028	0.348	101	1995	6
9	-144904	28640	149613	-0.127	0.330	101	1995	6
11	-26593	10881	21086	-0.037	0.281	101	1995	6
13	-113523	-57880	177951	-0.073	0.418	101	1992	9
15	-60696	-115335	166142	-0.296	0.524	101	1996	7
16	-1117	-31562	28519	-0.024	0.591	101	1992	9
17	-176378	-86886	243558	-0.129	0.523	101	1997	3
18	-26590	8443	22031	-0.045	0.257	101	1995	3
19	-25480	-25781	53328	-0.126	0.360	101	1993	6
20	-5393	-10800	20429	-0.347	0.170	101	1997	0
21	-37107	10990	47401	-0.252	0.414	101	2001	5
22	-21591	-54312	81124	-0.335	0.363	101	1996	1
23	-20556	8965	17805	-0.076	0.203	101	1996	10
24	-3849	13962	2692	-0.113	0.362	101	2000	8
25	-4287	9669	3825	-0.100	0.168	101	2000	6
26	-8843	10095	6896	-0.015	0.233	101	2000	5
28	-619	-706	716	0.044	0.014	101	1997	11
29	-619	1020	271	0.006	0.047	101	1999	2
30	-132161	103167	91945	0.013	0.370	141	1998	4
102	-9676	-24843	30197	-0.128	0.358	129	1995	1
105	-63446	-13742	76623	-0.044	0.253	140	1996	3
106	-52476	-23592	71365	-0.079	0.389	140	1996	3
107	-259008	-77030	336926	-0.115	0.435	140	1996	5
108	-104244	-24136	123599	-0.045	0.172	141	1997	2
109	-39631	16443	37747	-0.027	0.092	141	2000	6

Table 10

Standard errors and t statistics for coefficients in Table 9

Pool num.	Coefficient Standard Errors: Constant	Structural break dummy	River tons/ normal	(Price/ normal price)*normal tons	Coefficient t-statistics: Constant	Structural break dummy	River tons/ normal	(Price/ normal price)*normal tons
(1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
3	4850.4	3506.3	4747.1	0.086	-0.95	-2.29	1.36	-0.46
4	60959.4	33703.1	52286.3	0.066	-2.96	-4.18	7.32	-3.57
6	7402.0	3571.2	7246.0	0.077	-5.99	4.33	4.94	-0.36
9	24250.8	11755.0	23893.4	0.072	-5.98	2.44	6.26	-1.76
11	5565.3	2637.5	5377.8	0.085	-4.78	4.13	3.92	-0.44
13	30314.1	16805.8	26175.5	0.081	-3.74	-3.44	6.80	-0.90
15	31392.5	13567.2	29667.2	0.100	-1.93	-8.50	5.60	-2.97
16	6122.5	3382.9	5224.2	0.071	-0.18	-9.33	5.46	-0.34
17	30600.3	13345.5	29976.2	0.095	-5.76	-6.51	8.13	-1.35
18	5478.9	2676.3	5374.2	0.126	-4.85	3.15	4.10	-0.35
19	11593.9	5791.7	10149.0	0.104	-2.20	-4.45	5.25	-1.21
20	7840.1	3412.2	7576.2	0.151	-0.69	-3.17	2.70	-2.30
21	6581.3	3973.3	6606.8	0.088	-5.64	2.77	7.17	-2.87
22	20536.6	8824.6	19094.6	0.120	-1.05	-6.15	4.25	-2.79
23	5945.0	2604.2	5607.6	0.111	-3.46	3.44	3.18	-0.68
24	3545.8	1980.6	3436.1	0.133	-1.09	7.05	0.78	-0.85
25	4427.1	2415.4	4299.3	0.104	-0.97	4.00	0.89	-0.96
26	3964.5	2143.8	3891.3	0.111	-2.23	4.71	1.77	-0.14
28	1545.4	707.3	1492.6	0.090	-0.40	-1.00	0.48	0.50
29	1059.4	511.9	1072.3	0.118	-0.58	1.99	0.25	0.05
30	28783.9	13456.6	28106.1	0.044	-4.59	7.67	3.27	0.29
102	7337.8	3871.5	7348.4	0.087	-1.32	-6.42	4.11	-1.48
105	12675.4	5715.0	12070.4	0.046	-5.01	-2.40	6.35	-0.96
106	9840.8	4414.7	9380.8	0.048	-5.33	-5.34	7.61	-1.63
107	39560.1	17482.2	37315.5	0.043	-6.55	-4.41	9.03	-2.68
108	26542.9	11783.6	25044.4	0.047	-3.93	-2.05	4.94	-0.97
109	13694.0	7419.1	13099.6	0.054	-2.89	2.22	2.88	-0.50

Table 11
Regression coefficients including inventory accumulation

Pool num.	Constant	Structural break dummy	Construct. Inventory	(Price/ normal price)* inventory	River tons/ normal	(Price/ normal price)*normal tons	R-square
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
3	2844.6	-12542.7	0.196	-0.031	4733.3	-0.059	0.229
4	-182194.4	-144465.9	-0.048	0.076	383753.7	-0.209	0.493
6	-43498.4	12865.6	-0.261	0.344	33946.5	0.011	0.387
9	-166738.2	18746.0	0.132	-0.100	160456.3	-0.093	0.348
11	-28729.2	10512.0	0.083	-0.079	22893.1	-0.028	0.284
13	-120219.4	-56362.4	0.150	-0.126	186876.7	-0.103	0.438
15	-89892.0	-102867.5	0.159	-0.131	175041.1	-0.268	0.537
16	3882.9	-32035.7	-0.354	0.449	25019.4	-0.079	0.649
17	-197006.8	-81677.4	0.114	-0.045	236274.8	-0.081	0.551
18	-16938.8	9050.6	-0.290	0.321	15546.6	-0.184	0.329
19	-20379.5	-26396.5	-0.138	0.138	51141.8	-0.170	0.380
20	-10686.1	-8501.5	0.076	-0.026	21097.5	-0.324	0.191
21	-42461.4	16680.0	0.184	-0.074	46964.0	-0.198	0.485
22	-27449.4	-54510.5	-0.158	0.186	87659.5	-0.293	0.381
23	-18845.7	6673.0	0.001	0.069	19648.6	-0.070	0.229
24	-10714.6	8769.1	0.885	-0.552	6183.8	-0.052	0.484
25	-3679.7	8781.5	0.035	0.019	3162.8	-0.110	0.191
26	-10033.0	9192.8	-0.140	0.223	8356.5	0.001	0.277
28	-2314.9	-138.7	0.223	-0.100	1705.3	0.036	0.091
29	-1244.8	1309.4	0.038	0.043	338.0	-0.047	0.084
30	-137349.0	97072.8	0.148	-0.068	89060.3	0.013	0.398
102	-6500.8	-21871.6	0.035	0.097	26151.1	-0.189	0.402
105	-60328.3	-9543.9	-0.085	0.139	75578.6	-0.057	0.291
106	-48766.8	-22099.1	-0.041	0.102	71057.9	-0.067	0.416
107	-214582.1	-100994.0	-0.034	0.130	336057.8	-0.074	0.491
108	-81709.2	-23317.4	0.063	0.043	114352.9	-0.074	0.245
109	-37432.8	-5105.0	0.182	-0.010	39345.6	-0.055	0.204

Table 12

Standard Errors (cols. 2-7) and T statistics (cols. 8-11) for Coefficients in Table 11

Pool num.	Constant	Structural break dummy	Construct. Inventory	(Price / normal price) * inventory	River tons/ normal	(Price/ normal price)*normal tons	Constant	Structural break dummy	Construct. Inventory	(Price/ normal price)* inventory	River tons / normal	(Price / normal price) * normal tons
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(10)	(11)
3	5229.6	3373.2	0.116	0.104	4660.6	0.083	0.54	-3.72	1.69	-0.30	1.02	-0.70
4	68719.8	34583.7	0.120	0.101	55248.8	0.069	-2.65	-4.18	-0.40	0.75	6.95	-3.03
6	7508.0	3856.5	0.170	0.184	7501.6	0.077	-5.79	3.34	-1.54	1.87	4.53	0.15
9	28287.8	14288.9	0.095	0.090	25493.5	0.075	-5.89	1.31	1.39	-1.10	6.29	-1.23
11	6755.5	3561.6	0.130	0.117	6157.9	0.087	-4.25	2.95	0.64	-0.67	3.72	-0.32
13	30434.5	16781.1	0.096	0.093	26973.4	0.083	-3.95	-3.36	1.56	-1.35	6.93	-1.23
15	36239.7	15852.1	0.135	0.137	30221.7	0.101	-2.48	-6.49	1.17	-0.95	5.79	-2.64
16	6062.9	3178.9	0.156	0.156	5092.1	0.068	0.64	-10.08	-2.27	2.87	4.91	-1.16
17	32258.6	14651.8	0.159	0.154	29993.5	0.096	-6.11	-5.57	0.72	-0.29	7.88	-0.85
18	6240.7	3133.2	0.096	0.101	5750.4	0.130	-2.71	2.89	-3.01	3.19	2.70	-1.42
19	12897.6	6320.3	0.082	0.079	10554.0	0.107	-1.58	-4.18	-1.68	1.76	4.85	-1.59
20	8886.4	3990.8	0.182	0.172	7572.8	0.157	-1.20	-2.13	0.42	-0.15	2.79	-2.07
21	7523.1	4101.2	0.139	0.122	6303.9	0.107	-5.64	4.07	1.32	-0.61	7.45	-1.84
22	21037.0	8914.2	0.135	0.135	19484.8	0.124	-1.30	-6.12	-1.17	1.38	4.50	-2.37
23	6285.9	2884.8	0.189	0.199	5791.5	0.118	-3.00	2.31	0.00	0.35	3.39	-0.59
24	3653.6	2143.5	0.212	0.164	3318.4	0.126	-2.93	4.09	4.18	-3.36	1.86	-0.42
25	4440.2	2526.7	0.197	0.200	4309.3	0.104	-0.83	3.48	0.18	0.09	0.73	-1.06
26	4084.4	2259.5	0.164	0.163	3973.3	0.110	-2.46	4.07	-0.85	1.36	2.10	0.01
28	1625.1	747.0	0.151	0.135	1508.3	0.089	-1.42	-0.19	1.48	-0.74	1.13	0.40
29	1459.4	535.3	0.133	0.128	1138.5	0.163	-0.85	2.45	0.29	0.33	0.30	-0.29
30	29664.5	13966.9	0.108	0.097	28451.6	0.047	-4.63	6.95	1.37	-0.70	3.13	0.27
102	7875.5	4019.7	0.152	0.175	7569.4	0.090	-0.83	-5.44	0.23	0.56	3.45	-2.11
105	15066.6	6808.0	0.066	0.072	12330.3	0.047	-4.00	-1.40	-1.28	1.94	6.13	-1.23
106	11851.8	4749.6	0.076	0.077	9655.9	0.051	-4.11	-4.65	-0.54	1.34	7.36	-1.33
107	44207.8	18512.5	0.053	0.060	36435.1	0.046	-4.85	-5.46	-0.65	2.17	9.22	-1.62
108	26287.2	12380.1	0.131	0.137	24274.3	0.047	-3.11	-1.88	0.48	0.31	4.71	-1.59
109	12927.4	8776.8	0.139	0.125	12385.5	0.053	-2.90	-0.58	1.32	-0.08	3.18	-1.04

Table 13

Regression coefficients including alternative measures of inventory accumulation

Pool num. (1)	Constant (2)	Structural break dummy (3)	Inventory increment (4)	(Price/ normal price)* inventory increment (5)	River tons/ normal (6)	(Price/ normal price)*normal tons (7)	R-square (8)
3	-6008.28	-9135.55	-0.53449	0.360867	9203.528	-0.083	0.0996
4	-202412	-137109	-0.5273	0.06678	402218.6	-0.216	0.5829
6	-41560.2	16620.41	-0.26583	0.079803	30398.36	0.0208	0.3501
9	-153994	31947.65	-0.75614	0.25455	157568.8	-0.122	0.4647
11	-25043.9	11672.62	0.155591	-0.09471	17178.16	0.0011	0.2874
13	-92227.7	-67127.1	0.369746	-0.80935	151087.3	-0.002	0.5661
15	-48315.4	-106854	-1.07733	0.451183	131105.5	-0.167	0.6969
16	1022.551	-32271.1	0.51364	-0.4877	26581.15	-0.019	0.5635
17	-166434	-84076.5	0.329272	-0.79062	211775	-0.014	0.5922
18	-25579.3	8368.889	0.03103	-0.29919	19256.12	0.0309	0.348
19	-21741.7	-25236.4	-0.28993	-0.21729	44514.69	-0.028	0.4665
20	-6069.74	-8609.9	0.01852	-0.47145	14910.41	-0.183	0.4043
21	-35649.7	15248.05	-0.46374	0.309335	41570.1	-0.17	0.4442
22	-26855	-52042.4	-0.96429	0.570153	73848.89	-0.209	0.4002
23	-24170.7	7955.813	-0.71434	0.622634	21774.56	-0.074	0.2239
24	-2796.77	15549.86	-0.45754	0.473423	2526.712	-0.2	0.4331
25	-977.372	10137.75	-1.07754	0.953182	942.6444	-0.125	0.2152
26	-7096.22	9806.306	-0.16278	-0.13422	5337.095	-0.025	0.2829
28	-929.452	-829.731	-0.05793	0.016714	1029.696	0.0482	0.0187
29	-527.779	797.4351	-0.6426	0.535726	538.3641	-0.042	0.0922
30	-119375	103541.5	0.032475	-0.4159	79369.96	0.0071	0.4635
102	-6238.98	-23248.8	-0.97902	0.633619	25385.7	-0.127	0.4689
105	-65731.5	-14598.3	-0.5024	0.136398	82143.24	-0.065	0.3839
106	-49672.5	-24674.7	-0.15901	-0.10844	69608.98	-0.08	0.4387
107	-261146	-81340.5	-0.31631	-0.0361	343226.6	-0.114	0.5102
108	-95953.4	-21735.1	0.198648	-0.52098	115561.9	-0.056	0.2771
109	-41350.9	16477.68	1.033788	-1.06409	38847.71	-0.022	0.1288

Table 14

Standard Errors for Coefficients in Table 13

	Coefficient Standard Errors					
Pool num.	Constant	Structural break dummy	Inventory increment	(Price/ normal price)* inventory increment	River tons/ normal	(Price/ normal price)*normal tons
(1)	(2)	(3)	(4)	(5)	(6)	(7)
3	5637.55	3928.959	0.757	0.7519	5674.65	0.1079
4	57248	30739	0.353	0.3307	51478.2	0.0696
6	8085.49	3861.163	0.512	0.4983	8055.64	0.09
9	24814	11785.09	0.444	0.4428	25356.6	0.0793
11	6044.95	2785.487	0.549	0.5424	5813.25	0.0897
13	27735.2	14636.26	0.453	0.4239	24786.5	0.0719
15	26467.7	11434.19	0.449	0.46	25588.3	0.0841
16	6975.4	3821.521	0.596	0.591	6024.34	0.0783
17	29981.9	12979.33	0.565	0.5636	31059.8	0.0932
18	5543.99	2581.866	0.46	0.4024	5435.66	0.1325
19	11178.3	5606.085	0.482	0.4599	10101.2	0.1104
20	5982.11	2734.863	0.567	0.5497	5930.81	0.1252
21	6693.93	4013.134	0.668	0.6984	7059.77	0.0961
22	21707.7	9048.102	0.663	0.6408	20150.6	0.1368
23	6731.15	2919.637	0.629	0.6501	6410.59	0.1183
24	3913.62	2144.127	0.564	0.5995	3783.06	0.1484
25	5073.83	2640.679	0.683	0.7248	4904.86	0.1118
26	4343.62	2287.73	0.63	0.6456	4307.29	0.1148
28	1818.59	815.6744	0.748	0.6786	1742.87	0.0983
29	1036.81	525.9797	0.659	0.7411	1131.02	0.1393
30	27197.6	12677.85	0.412	0.4056	26566.5	0.0414
102	7013.42	3819.337	0.264	0.2773	7237.27	0.0844
105	11691.5	5291.258	0.356	0.3425	11257.2	0.0428
106	9651.21	4379.244	0.352	0.3238	9384.34	0.0472
107	37846.6	16736.15	0.347	0.3228	36165.8	0.0404
108	24109.8	10783.75	0.329	0.3199	22783.5	0.0427
109	13548.4	7302.263	0.461	0.4556	12991.4	0.0534

Table 15
T-Statistics for Coefficients in Table 13

Pool num.	Constant	Structural break dummy	Inventory increment	(Price/ normal price)* inventory increment	River tons/ normal	(Price/ normal price)* normal tons
(1)	(2)	(3)	(4)	(5)	(4)	(5)
3	-1.07	-2.33	-0.71	0.48	1.62	-0.77
4	-3.54	-4.46	-1.49	0.20	7.81	-3.11
6	-5.14	4.30	-0.52	0.16	3.77	0.23
9	-6.21	2.71	-1.70	0.57	6.21	-1.54
11	-4.14	4.19	0.28	-0.17	2.96	0.01
13	-3.33	-4.59	0.82	-1.91	6.10	-0.03
15	-1.83	-9.35	-2.40	0.98	5.12	-1.98
16	0.15	-8.44	0.86	-0.83	4.41	-0.25
17	-5.55	-6.48	0.58	-1.40	6.82	-0.15
18	-4.61	3.24	0.07	-0.74	3.54	0.23
19	-1.94	-4.50	-0.60	-0.47	4.41	-0.25
20	-1.01	-3.15	0.03	-0.86	2.51	-1.46
21	-5.33	3.80	-0.69	0.44	5.89	-1.77
22	-1.24	-5.75	-1.45	0.89	3.66	-1.53
23	-3.59	2.72	-1.14	0.96	3.40	-0.63
24	-0.71	7.25	-0.81	0.79	0.67	-1.35
25	-0.19	3.84	-1.58	1.32	0.19	-1.11
26	-1.63	4.29	-0.26	-0.21	1.24	-0.22
28	-0.51	-1.02	-0.08	0.02	0.59	0.49
29	-0.51	1.52	-0.98	0.72	0.48	-0.30
30	-4.39	8.17	0.08	-1.03	2.99	0.17
102	-0.89	-6.09	-3.71	2.29	3.51	-1.50
105	-5.62	-2.76	-1.41	0.40	7.30	-1.52
106	-5.15	-5.63	-0.45	-0.33	7.42	-1.70
107	-6.90	-4.86	-0.91	-0.11	9.49	-2.82
108	-3.98	-2.02	0.60	-1.63	5.07	-1.32
109	-3.05	2.26	2.24	-2.34	2.99	-0.42

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